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FURTHER DEVELOPMENT OF THE GEOTOOL SEISMIC ANALYSIS SYSTEM

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The principal goal of this project was to make specific enhancements to the seismic analysis program, geotool, and generate program documentation. geotool is an X windows-based graphics tool for displaying waveforms and performing basic analysis operations in a highly interactive and flexible environment where user analysis needs are diverse, while at the same time providing a common platform of data I/O and graphics functionality. This report contains a description of the enhancements made to the program. A user's manual is provided separately, entitled "geotool Sourcebook". This latter document and the program are available by anonymous ftp from the Center for Monitoring Research (formerly Center for Seismic Studies).

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1. OBJECTIVES

The principal goal of this project was to make specific enhancements to the seismic analysis program, "geotool", and generate program documentation. "geotool" is an X Windows-based graphics tool for displaying wave forms and performing basic analysis operations in a highly interactive and flexible environment. The enhancements included in this project were aimed at increasing the program's versatility in a research environment where user analysis needs are diverse, while at the same time providing a common platform of data I/O and graphics functionality.

This report consists of a brief introduction followed by several sections describing the enhancements made to the program. A user's manual is provided separately entitled "geotool Sourcebook". This latter document as well as the program itself is available by anonymous ftp from the Center for Monitoring Research. They can be found in the directory /pub/coyne/geotool as compressed "tar" files.

2. INTRODUCTION

"geotool" was originally developed for ARPA/NMRO under the Nuclear Monitoring Research and Development (NMRD) initiative to construct a "Research Testbed" at the Center for Seismic Studies (CSS), and it is now widely used in both the nuclear monitoring and general seismic research communities. Portability was a key design goal to enable the program to be used in a variety of computing environments. An X window server and a UNIX operating system are the basic requirements. Initially developed on SUN computers, the software has since been ported to a number of UNIX platforms, including HP, IBM, Linux and SGI.

"geotool" can interface with specialized software such as the ISIS interprocess communication system and an ORACLE database server, which allows it to be integrated within the Intelligent Monitoring System (IMS) at the Center for Monitoring Research, but versions of the program which do not depend on ISIS and ORACLE are available. The primary data format is CSS-3.0, which can be read directly from disk files or from a relational database.

The following sections describe the enhancements that were made to the program as part of this project.

3. MODULARITY

Several aspects of "geotool" were modularized to improve its maintainability and also provide for easy methods of extending the functionality of the program. The user interface of "geotool" is completely defined by X resources using the Widget Creation Library [Smith and Nye, 1992]. This separates the interface from the C code, and allows the entire interface to be customized on a local or per-user basis. As explained in Chapter 6 of the "geotool Sourcebook", a naming convention was adopted for all interface elements or widgets, such as buttons, text fields or plotting windows, which makes it possible to identify widgets by looking only at the interface and not the C code. Through X resources, the attributes of any widget, such as size, position, font, color, text, etc., can be accessed and modified.

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The C code in "geotool" was divided into three major parts: the I/O routines, the analysis functions and the core part of "geotool". The I/O routines and the analysis functions are decoupled from the core of "geotool" and communicate with the "geotool" core via an Application Programmer's Interface. Consequently, these parts of "geotool" can be extended without modifying the core part of "geotool" by using shared library technology.

The core part of "geotool" manages the data after it has been read and provides graphic services via the widget set developed for "geotool". Some data attributes are stored in a local X resource database maintained by "geotool". The seismic data stored in "geotool" are organized in three autonomous lists of wave forms, arrivals and origins. This is an improvement that greatly increases the flexibility for handling data.

4. SHARED LIBRARIES

Shared library technology has been exploited as a mechanism for adding functionality to "geotool" without requiring the core part of the program to be modified or even recompiled. The I/O routine interfaces have been standardized, which allows the easy addition of new data formats. There is a suite of prototype I/O routines with standardized arguments. For example, the basic "geotool" reads three different formats: CSS-2.8/3.0, SAC and ASCII. Each of these formats has a routine for reading wave form data; cssReadData, sacReadData and asciiReadData. The argument list, or input and output to the ReadData prototype routine is defined to be format independent.

Similarly, there are other prototype I/O routines, such as ReadArrival, AddArrival, ReadOrigin, etc., and the corresponding format specific routines cssReadArrival, sacReadArrival, asciiReadArrival, etc. A new data format can be added to "geotool" through the use of X resources and shared libraries, without requiring any changes to the code or even recompiling the code. For example, to add a new data format called "binary" to the program, the formatList resource would be set as "geotool.formatList: css,sac,ascii,binary". A shared library, mylib.so.1, containing binary versions of the prototype I/O routines would be created and identified to "geotool" at run time with a resource line "geotool.binary.sharedLib: mylib.so.1". "geotool" dynamically links to the "binary" I/O routines, whose names are identified with resources like "geotool.binary.readDataCallback: binaryReadData".

"geotool" automatically determines the format of a data file by attempting to read with each format's ReadData routine. It is not necessary to have a complete suite of I/O routines for each format. For example, if there were no binaryAddArrival routine identified, then the add-arrival function in "geotool" would give a warning for binary data, but other functions would behave normally.

Shared library technology has also been utilized to isolate "geotool"'s analysis functions from the data I/O and graphics parts of "geotool". It is now straight forward to add additional analysis functions to the program, and this can be done on a user basis, without changing the core "geotool" C-code or recompiling. Additional windows can be added to the interface for controlling these new analysis tools. New windows containing plotting widgets, text fields and interface buttons can be described by X resources. At run time "geotool" reads a file of such resources and the new windows are created and tied to new analysis functions in a user defined shared library by the Widget Creation Library routines in the core part of "geotool".

5. CSS TABLES

Many more of the CSS-3.0 schema tables (Anderson et al., 1990) are now supported by "geotool". "geotool" reads each table from a flat file whose suffix is the table name. When wave form data is read via a file containing wfdisc records, the working directory is automatically searched for other CSS table-files which are linked to the wfdisc file by a common prefix. For example, if a file named "example.wfdisc" is read, the following table-files will be read, if they are found:

- example.affiliation
- example.arrival
- example.assoc
- example.instrument
- example.lastid
- example.origerr
- example.origin
- example.sensor
- example.site
- example.sitehan
- example.stassoc
- example.wftag

In addition, a user can point "geotool" to a directory of "global" table-files, that will be read and used throughout the session for all wfdisc-files input.

New text interfaces have been added to "geotool" for displaying the attributes of these tables. These interfaces are very flexible, allowing the user to interactively adjust the subset of attributes displayed, their order and format. Many attributes can also be edited in these interfaces and the changes will be recorded in the corresponding files.

6. SCHEME

A scheme language interpreter has been added to "geotool". The primary design goal for its addition was to facilitate automated processing. The goal was not to add functionality accessible only from scheme, but to provide a mechanism to drive what already exits. The rational for this design was to automate "geotool" to do mundane tasks while limiting scheme's prevalence, since most users are, at best, unfamiliar with the language.

This optional scheme interface is described in Chapter 7 of the "geotool Sourcebook". Basically it allows a user to automate any sequence of interactive commands that he would want to repeat often.

7. OTHER ENHANCEMENTS

There are many other miscellaneous enhancements that have been made to "geotool" and some of them are simply listed below.

- Several enhancements were made to the wave form display widget (the main window). More time scale options were added, such as variable, hours-minutes-seconds and epochal time. The graphics for moving and overlaying wave forms was improved, eliminating an irritating flicker from the previous version. Amplitude scales were added to the wave forms. Automatic non-overlapping wave form positioning is now an option.

- The File Listing window, in which wave form records are selected for input, has been enhanced by the addition of more constraints that can be used to specify a record subset.

- The Filter window now offers a list of predefined filter settings. A tapering option was added to the filter function.

- The FK plot identifies the point of maximum amplitude, and a Beam option was added to the FK menu that creates a beamed wave form for the azimuth and slowness corresponding to the maximum fk amplitude.

- Many options were added to the FT window: smoothing; display modes including median, percentiles, mean and standard deviation; amplitude or power; displacement, velocity or acceleration, dB relative to nanometers. CSS-3.0 instrument response files are automatically input in order to display spectra in nanometers.

- The Map window was enhanced by changing to a higher resolution coastline vector database and adding political boundaries. Origin error ellipses are now plotted and azimuth arcs are automatically tied to the Rotation and FK options. A simple mechanism for plotting user defined overlays on the map was added.

- "geotool" can serve as a wave form viewer when connected to World Wide Web browsers.

8. SUMMARY

The enhancements described in this report, along with the documentation increase the effectiveness and versatility the seismic analysis program "geotool". The program is already widely used in the ARPA seismological research community. A user's manual is available in Postscript format which can be downloaded along with the software package itself by anonymous ftp from the Center for Monitoring Research. This manual includes a tutorial for first-time users and installation notes for the package. Comments on the package may be directed to the Principal Investigators, ihenson@seismo.css.gov and coyne@seismo.css.gov.

9. REFERENCES

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